Deposited of Thin Silver Film by Plasma Focus Device

L. Karpiński, E. Kowalska-Strzęciwilk, M. Scholz, and B. Ulejczyk

Institute of Plasma Physics and Laser Microfusion, 23, Hery, Warszawa, 01-497, Poland
E-mail: lekarp@ifpilm.waw.pl

Abstract – Two kinds of the silver films were deposited on the surface of the implants in a Plasma Focus device. Process was carried out at 350 Pa of argon pressure. One film was deposited at 1 shot and second film was deposited at 10 shots. The differences between these films were observed by scanning electron microscope.

1. Introduction

Antibacterial properties of silver are known for many centuries. For a long time, there was a custom to hold water in silver vessel, to keep its freshness. But only in the beginning of XIX century scientists could prove that known thousand years that silver suppresses ability of pathogenic microorganisms. However, in the beginning, manufacture of silver was very expensive and application of antibiotics was more favorable. But there is a serious problem: at many bacteria, before susceptible to action of antibiotics, proof immunity subsequently has development, and in some cases they even eat them. Developed of new generation of antibiotics is expensive and time-consuming. Silver is inorganic material and bacteria have not become resistant to it.

Valuable virtue of silver caused that this material is intensively investigated [1–3]. In big concentration can be caused any allergy. For this reason, medical implants should not be made of silver. Moreover, the mechanical properties of other materials are much better. However it is possible to use silver as top layer on other materials to protect of they surfaces.

Silver can be deposited on all material, plastic [4–6], ceramics [7, 8] or other metals [9, 10]. The methods of deposition depend on the base materials. Electroplating, magneto-sputtering or ion gun are possible to use for silver deposition on metal. However, each of these methods has some faults. Electroplating needs the solvents and it is not environmental friendly method. Other methods operate at very low pressure, several Pa. In this paper, we present other technique. We use Plasma Focus device to obtain silver film on metallic implants. PF works also in vacuum, but the pressure is not so low. In this paper, we present first results of PF using for silver deposition and structure of obtained silver films.

2. Experimental setup

This PF consists essentially of coaxial electrode assembly and an alumina insulator (Fig. 1) across which the initial breakdown occurs. The outer electrode (12 stainless-steel bars of 12 mm in diameter) and center electrode – anode (25 mm in diameter). The anode is connected to the collector linked electrically through the spark-gap switch arrangement to the capacitor bank. The outer electrode is attached to a connection sleeve that provides vacuum seal. The cylindrical alumina insulator forms the vacuum seal between the connection sleeve and the collector. The central part of the insulator extends for about 3 cm along the anode into the vacuum chamber [11].

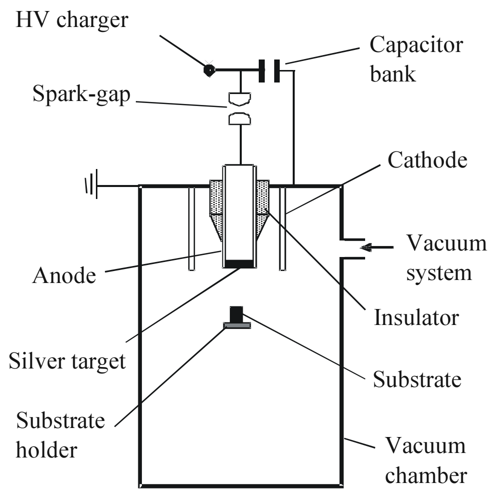


Fig. 1. Scheme of PF device

The anode is made of copper and a silver target was mounted in the anode tip. Silver target, which was used for layer deposition, are 99.95% of metals basis and was provide by Alfa Aesar. The outer electrode and vacuum chamber were kept at ground potential.

The films were grown on implants at room temperature. Implant (Fig. 2) was mounted on the holder axially under the anode. Distances between the film substrate and the top of the anode was 100 mm.

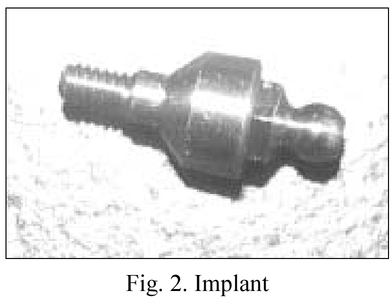


Fig. 2. Implant

The deposition process was proceeded in argon at 350 Pa of pressure. Stored energy in the capacitor bank was 3 kJ. One film was deposited at one shot (discharge) and second at 10 shots.

The topography of the layer was investigated using a scanning electron microscopy (SEM). The discharge parameters were recorded by digital oscilloscope Tektronix 3052. The typical traces of a current (I) and a current derivate (*dI/dt*) are shown in Fig. 3.

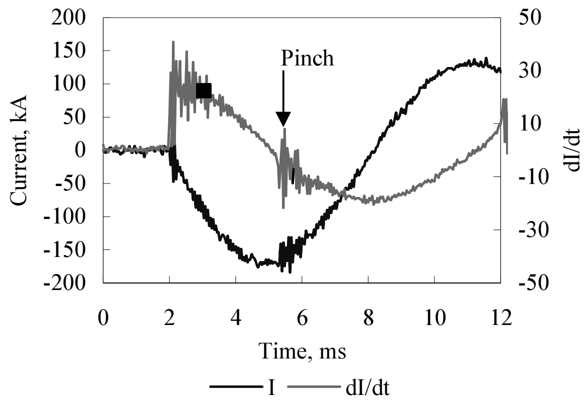
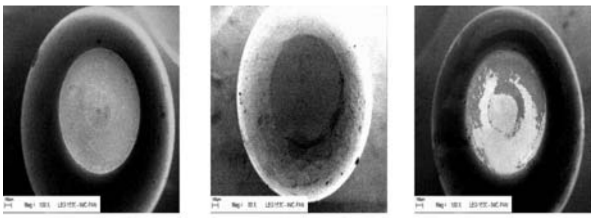


Fig. 3. Oscilograms of current and *dI/dt*

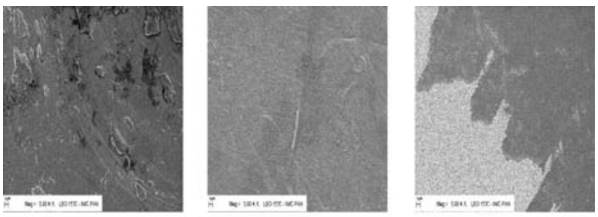
3. Results and discussion

Original surface of the implants and surface of the implants after deposition are shown in Figs. 4–7. There is shown that original surface differs from both silver film surfaces. Silver film, which was deposited at one shot, covers all the surface of implants. In the film, there are many holes, but the structure is homogeneity on all surfaces. In opposite silver film, which was deposited at 10 shots there is not homogeneity. In the small enlarge (Fig. 4, *c*) is shown that surface can be divided on two part.



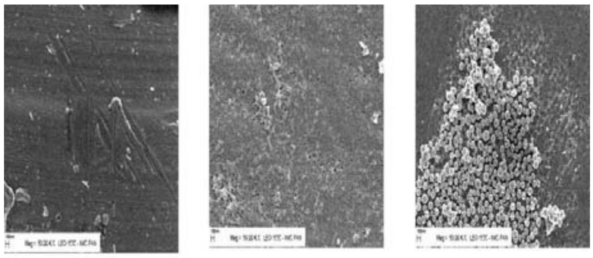
a *b* *c*

Fig. 4. SEM images of the implants surface. Enlarge 88 times: *a* – original surface; *b* – silver film deposited at 1 shot; *c* – silver film deposited at 10 shots



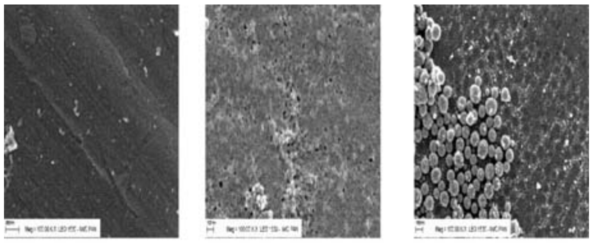
a *b* *c*

Fig. 5. SEM images of the implants surface. Enlarge 5000 times: *a* – original surface; *b* – silver film deposited at 1 shot; *c* – silver film deposited at 10 shots



a *b* *c*

Fig. 6. SEM images of the implants surface. Enlarge 50000 times: *a* – original surface; *b* – silver film deposited at 1 shot; *c* – silver film deposited at 10 shots



a *b* *c*

Fig. 7. SEM images of the implants surface. Enlarge 100000 times: *a* – original surface; *b* – silver film deposited at 1 shot; *c* – silver film deposited at 10 shots

One part is covered by many small drops. The second part is free from these drops, but the traces for drops are observed in the high enelarges (Figs. 6 and 7, *c*). It suggested that drops tear off from surface.

To explain why are these differences is necessary to mention some about Plasma Focus phenomena. During PF operating the working gas (in this case argon) is compressed and ionized. Ions mowed from anode and electrons moved to anode.

If on the way of ions are any material then ions interacted with it. The material melted when ions beam act and condensed when ions beam stop action. Duration time of ions bean is short but energy of ions is high. Based on earlier researches at plasma pressure measurements it is possible to estimate that at 10 cm from anode, 15 kV of charging voltage and 350 Pa of argon pressure, duration time of ions beam is about 300 ns and average energy of argon ions is about 95 kJ [12].

So, at first shot this ions beam hit in the surface of base material and activate it, changed. Next, the silver, which was emitted from the anode, by the electron beam and the anode interaction arrive on the surface and deposited on it. It can be worth for mention that energy of electron beam is estimated on 8% of the stored energy in capacitor bank.

In Figures 4–7, *b* is showed that silver quite uniformly covered base material and it suggested that the implant surface was characterized by well wetability by silver. Probably the surface was cleaned and activated and hot. It should be mention that whole element is cold but the top layer, which is exhibited on argon ions action can be hot. All of these phenomena occur in first shot. In the next shot also first arrive to implant surface argon ions beam. However, the argon beam interacted with the silver film. The film melted and condensed. The drops shape of silver indicates that wetability of base material by silver is not so high and a connection between base material and silver, which was come into existence in first shot, is destroyed. Probably the temperature of base material is too small to make well connection between two various materials. The energy from ions beam was used to heat top layer (silver) on the sample and the base material was to cold for well cover by silver. Weak bond between silver drops and base material caused that drops easy come off form implant. It means that thin films should be deposited by one shot or the implant should be heat. In next experiments, we planed heat implants to various temperatures.

4. Summary and conclusions

The Plasma Focus device can be used to deposition of thin silver film on the implants. The film should be deposited during one shot, because in this condition silver film covered all surface. If the process is running by 10 shots the silver film changes structure into drops. These drops are not well connecter to base material and often come off.

References

[1] A.D. Russell and I. Chopra, *Understanding antibacterial action and resistance, Hemel Hempstead*, Hertfordshire, Ellis Horwiid, 1996, chapter 3.

[2] M. Kawashita, S. Tsuneyama, F. Miyaji, T. Kobubo, H. Kozuka, and K. Yamamoto, Biomaterials **21**, 393 (2000).

[3] P.L. Taylora, A.L. Usshera, and R.E. Burrella, Biomaterials **26**, 7221 (2005).

[4] S. Chen, J. Liu, and H. Zeng, J. of Materials Science **40**, 6223 (2005).

[5] S.H. Jeong, S.Y. Yeo, and S.C. Yi, J. of Materials Science **40**, 5407 (2005).

[6] J.E. Gray, P.R. Norton, R. Alnouno, C.L. Marolda, M.A. Valvano, and K. Griffiths, Biomaterials **24**, 2759 (2003).

[7] L.A. Brook, P. Evans, H.A. Foster, M.E. Pemble, A. Steele, D.W. Sheel, and H.M. Yates, J. of Photochemistry and Photobiology A: Chemistry **187**, 53 (2007).

[8] D.W. Han, M.S. Lee, M.H. Lee, M. Uzawa, and J.C. Park, World J. of Microbiology & Biotechnology **21**, 921 (2005).

[9] G.J. Chi, S.W. Yao, J. Fan, W.G. Zhang, and H.Z. Wang, Surface and Coatings Technology **157**, 162 (2002).

[10] Y.Z. Wan, S. Raman, F. He, and Y. Huang, Vacuum **81**, 1114 (2007).

[11] M. Chernyshova, I. Ivanova-Stanik, L. Karpiński, M. Scholz, B. Ulejczyk, I.N. Demchenko, and J.K. Lee, Czechoslovak Journal of Physics, B **56**, 237 (2006).

[12] O.V. Byrka, A.N. Bandura, I.E. Garkusha, V.I. Teresin, L. Karpiński, R. Miklaszewski, M. Scholz, and B. Ulejczyk, *in Proc. 34th EPS Conference on Plasma Phys*., Warsaw, 2007 ECA Vol. 31F, pp. 5.072.